

1                   **PROCESS FOR THE UPGRADING OF THE PRODUCTS**  
2                   **OF FISCHER-TROPSCH PROCESSES**

3  
4                   FIELD OF THE INVENTION

5  
6       The instant invention is directed to a means for hydroprocessing  
7       Fischer-Tropsch products in which hydrocracking of distillate range  
8       components is minimized.

9  
10                  BACKGROUND OF THE INVENTION

11  
12       The majority of combustible liquid fuel used in the world today is derived from  
13       crude oil. However, there are several limitations to using crude oil as a fuel  
14       source. For example, crude oil is in limited supply; it includes aromatic  
15       compounds believed to cause cancer and contains sulfur and nitrogen-  
16       containing compounds that can adversely affect the environment.

17  
18       Alternative sources for developing combustible liquid fuel are desirable. An  
19       abundant source is natural gas. The conversion of natural gas to combustible  
20       liquid fuel typically involves converting the natural gas, which is mostly  
21       methane, to synthesis gas, or syngas, which is a mixture of carbon monoxide  
22       and hydrogen. An advantage of using fuels prepared from syngas is that they  
23       typically do not contain appreciable amounts of nitrogen and sulfur and  
24       generally do not contain aromatic compounds. Accordingly, they have less  
25       health and environmental impact than conventional petroleum-based fuels.  
26       Fischer-Tropsch synthesis is a preferred means for converting syngas to  
27       higher molecular weight hydrocarbon products.

28  
29       Fischer-Tropsch synthesis is often performed under conditions which produce  
30       a large quantity of C<sub>20</sub>+ wax, which must be hydroprocessed to provide  
31       distillate fuels. Often, the wax is hydrocracked to reduce the chain length, and

1 then hydrotreated to reduce oxygenates and olefins to paraffins. Although  
2 some catalysts have been developed with selectivity for longer chain  
3 hydrocarbons, the hydrocracking tends to reduce the chain length of all of the  
4 hydrocarbons in the feed. When the feed includes hydrocarbons that are  
5 already in a desired range, for example, the distillate fuel range,  
6 hydrocracking of these hydrocarbons is undesirable.

7  
8 It would be advantageous to provide a method for hydroprocessing  
9 Fischer-Tropsch wax which minimizes the hydrocracking of hydrocarbons in  
10 the distillate fuel range. The present invention provides such methods.

11  
12 U.S. Pat. No. 6,583,186 discloses a means of hydroprocessing  
13 Fischer-Tropsch products without overcracking distillate components. In this  
14 scheme, however, all of the heavier, hydrocracked material is recombined  
15 with lighter materials, such as Fischer-Tropsch condensate and subsequently  
16 hydrotreated. There is no interstage separation step following hydrocracking,  
17 as in the instant invention.

18  
19 U.S. Pat. No. 6,224,747 discloses hydrocracking a VGO stream in a  
20 hydrocracking reaction zone within an integrated hydroconversion process.  
21 Effluent from the hydrocracking reaction zone is combined, without interstage  
22 separation with a light aromatic-containing feed stream, and the blended  
23 stream is hydrotreated in a hydrotreating reaction zone. The hydrocracked  
24 effluent serves as a heat sink for the hydrotreating reaction zone. The  
25 integrated reaction system provides a single hydrogen supply and  
26 recirculation system for use in two reaction systems. This patent is not  
27 directed to hydroprocessing of Fischer-Tropsch products, as is the instant  
28 invention. Furthermore, there is no interstage separation between the  
29 hydrocracking and hydrotreating stages.

## SUMMARY OF THE INVENTION

The instant invention is directed to a means for hydroprocessing Fischer-Tropsch products in which hydrocracking of distillate range components is minimized. This results in reduction in capital investment, particularly for large scale plants, reduction in operating costs, and an increase in production of more valuable products.

The invention may be more particularly described as an integrated hydroconversion process for the treatment of Fischer-Tropsch products including a first hydrocarbon stream comprising a wax and a second hydrocarbon stream comprising a condensate, the process having at least two stages, a hydrocracking stage and a hydrotreating stage, each stage possessing at least one reaction zone, wherein the process comprises the following steps:

- (a) combining a first hydrocarbon stream with a first hydrogen-rich gaseous stream to form a first feedstock;
- (b) passing the first feedstock of step (a) to a hydrocracking reaction zone, which is maintained at hydrocracking conditions, to form a hydrocracking zone effluent comprising normally liquid phase components and normally gaseous phase components;
- (c) passing the hydrocracking zone effluent of step (b) to a heat exchanger or series of exchangers, where it is cooled;
- (d) separating the components of the cooled effluent of step (c) into a vapor stream and a liquid stream;

- 1 (e) combining the vapor stream of step (d) with the second hydrocarbon  
2 stream to form a second feedstock, the liquid stream of step (d) being  
3 passed to lubricant production or to further processing for manufacture  
4 of fuel and diesel products;  
5  
6 (f) passing the second feedstock of step (e) to a hydrotreating zone, which  
7 is maintained at conditions sufficient for reducing the content of sulfur,  
8 nitrogen, oxygenates and unsaturates present in the second  
9 hydrocarbon stream, to form a hydrotreating zone effluent;  
10  
11 (g) separating the hydrotreating zone effluent of step (f) into a liquid stream  
12 comprising products and a second hydrogen-rich gaseous stream;  
13  
14 (h) passing the liquid stream of step (g) to further processing, and passing  
15 the hydrogen-rich gaseous stream of step (g) to further separation into a  
16 light hydrogen-rich gaseous stream, and a stream comprising liquid  
17 products; and  
18  
19 (i) recycling at least a portion of the hydrogen-rich gaseous stream of  
20 step (h) to the hydrocracking zone and hydrotreating zones.  
21

#### 22 BRIEF DESCRIPTION OF THE FIGURES

- 23  
24 Figure 1 illustrates the basic flow scheme of the preferred embodiment.  
25  
26 Figures 2 and 3 show variations of the basic flow scheme.  
27

## DETAILED DESCRIPTION OF THE INVENTION

### **Feeds**

The products from Fischer-Tropsch reactions performed in slurry bed reactors generally include a light fraction (also known as a condensate fraction) and a heavy fraction (also known as a wax fraction). In the instant invention, the wax fraction comprises the feed to the hydrocracker and the condensate comprises a portion of the feed to the hydrotreater. The condensate includes hydrocarbons boiling below about 700°F (e.g., tail gases through middle distillates, with increasingly smaller amounts of material up to about C<sub>30</sub>), preferably in the range C<sub>5</sub>-650°F. The waxy reaction product includes hydrocarbons boiling above about 600°F (e.g., vacuum gas oil through heavy paraffins with increasingly smaller amounts of material down to about C<sub>10</sub>).

When the gaseous reaction product (part of the condensate) from the Fischer-Tropsch synthesis step is being cooled and condensed and various fractions collected, the first liquid fractions collected tend to have higher average molecular weights than subsequent fractions.

The light and heavy fractions described above can optionally be combined with hydrocarbons from other streams, for example, streams from petroleum refining. The light fractions can be combined, for example, with similar fractions obtained from the fractional distillation of crude oil and/or liquids recovered from natural gas wells. The heavy fractions can be combined, for example, with waxy crude oils, crude oils and/or slack waxes from petroleum deoiling and dewaxing operations.

The light fraction typically includes a mixture of hydrocarbons, including mono-olefins and alcohols. The mono-olefins are typically present in an

amount of at least about 5.0 wt% of the fraction. The alcohols are usually present in an amount typically of at least about 0.5 wt% or more.

#### **Conditions - Hydrocracking Stage**

Reaction conditions in the hydrocracking reaction zone include a reaction temperature between about 250°C and about 500°C (482°F-932°F), pressures from about 3.5 MPa to about 24.2 MPa (500-3,500 psi), and a feed rate (vol oil/vol cat h) from about 0.1 to about 20 hr<sup>-1</sup>. Hydrogen circulation rates are generally in the range from about 350 std liters H<sub>2</sub>/kg oil to 1780 std liters H<sub>2</sub>/kg oil (2,310-11,750 standard cubic feet per barrel). Preferred reaction temperatures range from about 340°C to about 455°C (644°F-851°F). Preferred total reaction pressures range from about 6.9 MPa to about 20.7 MPa (1,000-3,000 psi). With the preferred catalyst system, it has been found that preferred process conditions include contacting a hydrocarbon feedstock with hydrogen under hydrocracking conditions comprising a pressure of about 6.9 MPa to about 20.7 MPa (1,000-3000 psi), a gas to oil ratio between about 379-909 std liters H<sub>2</sub>/kg oil (2,500-6,000 scf/bbl), a LHSV of between about 0.5-1.5 hr<sup>-1</sup>, and a temperature in the range of 350°C to 427°C (662°F-800°F).

Conditions in the hydrocracking stage are sufficient to effect a boiling point conversion of at least 25%, preferably between 30% and 90%. Conversion involves breaking the relatively high boiling molecules of the feed into lower boiling components.

#### **Catalysts - Hydrocracking Stage**

The hydrocracking stage and the hydrotreating stage may each contain one or more catalysts. If more than one distinct catalyst is present in either of the stages, they may either be blended or be present as distinct layers. Layered

1 catalyst systems are taught, for example, in U.S. Patent No. 4,990,243, the  
2 disclosure of which is incorporated herein by reference for all purposes.  
3 Hydrocracking catalysts useful for the hydrocracking stage are well known. In  
4 general, the hydrocracking catalyst comprises a cracking component and a  
5 hydrogenation component on an oxide support material or binder. The  
6 cracking component may include an amorphous cracking component and/or a  
7 zeolite, such as a Y-type zeolite, an ultrastable Y type zeolite, or a  
8 dealuminated zeolite. A suitable amorphous cracking component is  
9 silica-alumina.

10  
11 The hydrogenation component of the catalyst particles is selected from those  
12 elements known to provide catalytic hydrogenation activity. At least one metal  
13 component selected from the Group VIII (IUPAC Notation) elements and/or  
14 from the Group VI (IUPAC Notation) elements are generally chosen. Group V  
15 elements include chromium, molybdenum and tungsten. Group VIII elements  
16 include iron, cobalt, nickel, ruthenium, rhodium, palladium, osmium, iridium  
17 and platinum. The amount(s) of hydrogenation component(s) in the catalyst  
18 suitably range from about 0.5% to about 10% by weight of Group VIII metal  
19 component(s) and from about 5% to about 25% by weight of Group VI metal  
20 component(s), calculated as metal oxide(s) per 100 parts by weight of total  
21 catalyst, where the percentages by weight are based on the weight of the  
22 catalyst before sulfiding. The hydrogenation components in the catalyst may  
23 be in the oxidic and/or the sulphidic form. If a combination of at least a  
24 Group VI and a Group VIII metal component is present as (mixed) oxides, it  
25 will be subjected to a sulfiding treatment prior to proper use in hydrocracking.  
26 Suitably, the catalyst comprises one or more components of nickel and/or  
27 cobalt and one or more components of molybdenum and/or tungsten or one  
28 or more components of platinum and/or palladium. Catalysts containing  
29 nickel and molybdenum, nickel and tungsten, platinum and/or palladium are  
30 particularly preferred.

1 The hydrocracking catalyst particles of this invention may be prepared by  
2 blending, or co-mulling, active sources of hydrogenation metals with a binder.  
3 Examples of suitable binders include silica, alumina, clays, zirconia, titania,  
4 magnesia and silica-alumina. Preference is given to the use of alumina as  
5 binder. Other components, such as phosphorous, may be added as desired  
6 to tailor the catalyst particles for a desired application. The blended  
7 components are then shaped, such as by extrusion, dried and calcined at  
8 temperatures up to 649°C (1200°F) to produce the finished catalyst particles.  
9 Alternatively, equally suitable methods of preparing the amorphous catalyst  
10 particles include preparing oxide binder particles, such as by extrusion, drying  
11 and calcining, followed by depositing the hydrogenation metals on the oxide  
12 particles, using methods such as impregnation. The catalyst particles,  
13 containing the hydrogenation metals, are then further dried and calcined prior  
14 to use as a hydrocracking catalyst.

15

#### 16 **Conditions - Hydrotreater Stage**

17

18 The hydrotreater is maintained at conditions sufficient to remove at least a  
19 portion of the nitrogen, oxygen and unsaturated compounds from the second  
20 hydrocarbon stream. The hydrotreater will operate at a lower temperature  
21 than the hydrocracker, except for possible temperature gradients resulting  
22 from exothermic heating within the reaction zones, optionally moderated by  
23 the addition of relatively cooler streams into the one or more reaction zones.  
24 Feed rate of the reactant liquid stream through the reaction zones will be in  
25 the region of 0.1 to 20 hr<sup>-1</sup> liquid hourly space velocity. Hydrotreating  
26 conditions typically used in the hydrotreater will include a reaction  
27 temperature between about 150°C and about 500°C (302°F-932°F),  
28 pressures from about 2.1 MPa to about 24.2 MPa (300-3,500 psig), and a  
29 feed rate (vol oil/vol cat h) from about 0.1 to about 20 hr<sup>-1</sup>. Hydrogen  
30 circulation rates are generally in the range from about 350 std liters H<sub>2</sub>/kg oil  
31 to 1780 std liters H<sub>2</sub>/kg oil (2,310-11,750 standard cubic feet per barrel).



1 Preferred reaction temperatures range from about 200°C to about 427°C  
2 (392°F-800°F). Preferred total reaction pressures range from about 6.9 MPa  
3 to about 20.7 MPa (1,000-3,000 psi).

4

5 The hydrotreating stage contains hydrotreating catalyst, maintained at  
6 hydrotreating conditions. Catalysts known for hydrotreating are useful for the  
7 hydrotreater. Such hydrotreating catalysts are suitable for hydroconversion of  
8 feedstocks containing sulfur, nitrogen, oxygenates and/or unsaturated  
9 molecules. Such catalysts generally contain at least one metal component  
10 selected from Group VIII (IUPAC Notation) and/or at least one metal  
11 component selected from the Group VI (IUPAC notation) elements. Group VI  
12 elements include chromium, molybdenum and tungsten. Group VIII elements  
13 include iron, cobalt and nickel. While the noble metals, especially palladium  
14 and/or platinum, may be included, alone or in combination with other  
15 elements, in the hydrotreating catalyst, use of the noble metals as  
16 hydrogenation components is not preferred. The amount(s) of hydrogenation  
17 component(s) in the catalyst suitably range from about 0.5% to about 10% by  
18 weight of Group VIII metal component(s) and from about 5% to about 25% by  
19 weight of Group VI metal component(s), calculated as metal oxide(s) per  
20 100 parts by weight of total catalyst, where the percentages by weight are  
21 based on the weight of the catalyst before sulfiding. The hydrogenation  
22 components in the catalyst may be in the oxidic and/or the sulfidic form. If a  
23 combination of at least a Group VI and a Group VIII metal component is  
24 present as (mixed) oxides, it will be subjected to a sulfiding treatment prior to  
25 proper use in hydrotreating. Suitably, the catalyst comprises one or more  
26 components of nickel and/or cobalt and one or more components of  
27 molybdenum and/or tungsten. Catalysts containing cobalt and molybdenum  
28 are particularly preferred.

29

30 The hydrotreating catalyst particles of this invention are suitably prepared by  
31 blending, or co-mulling, active sources of hydrogenation metals with a binder.

1 Examples of suitable binders include silica, alumina, clays, zirconia, titania,  
2 magnesia and silica-alumina. Preference is given to the use of alumina as  
3 binder. Other components, such as phosphorous, may be added as desired  
4 to tailor the catalyst particles for a desired application. The blended  
5 components are then shaped, such as by extrusion, dried and calcined at  
6 temperatures up to 649°C (1200°F) to produce the finished catalyst particles.  
7 Alternatively, equally suitable methods of preparing the amorphous catalyst  
8 particles include preparing oxide binder particles, such as by extrusion, drying  
9 and calcining, followed by depositing the hydrogenation metals on the oxide  
10 particles, using methods such as impregnation. The catalyst particles,  
11 containing the hydrogenation metals, are then further dried and calcined prior  
12 to use as a hydrotreating catalyst.  
13

14 The subject process is especially useful in the production of middle distillate  
15 fractions boiling in the range of about 121°C-371°C (250°F-700°F) as  
16 determined by the appropriate ASTM test procedure. By a middle distillate  
17 fraction having a boiling range of about 121°C-371°C (250°F-700°F) is meant  
18 that at least 75 vol%, preferably 85 vol%, of the components of the middle  
19 distillate have a normal boiling point of greater than about 121°C (250°F) and  
20 furthermore that at least about 75 vol%, preferably 85 vol%, of the  
21 components of the middle distillate have a normal boiling point of less than  
22 371°C (700°F). The term "middle distillate" is intended to include the diesel,  
23 jet fuel and kerosene boiling range fractions. The kerosene or jet fuel boiling  
24 point range is intended to refer to a temperature range of about 138°C-274°C  
25 (280°F-525°F), and the term "diesel boiling range" is intended to refer to  
26 hydrocarbon boiling points of about 121°C-371°C (250°F-700°F). Gasoline or  
27 naphtha is normally the C<sub>5</sub> to 204°C (400°F) endpoint fraction of available  
28 hydrocarbons. The boiling point ranges of the various product fractions  
29 recovered in any particular plant will vary with such factors as the  
30 characteristics of the hydrocarbon source, plant local markets, product prices,

1 etc. Reference is made to ASTM standards D 975 and D 3699 83 for further  
2 details on kerosene and diesel fuel properties.

3  
4 Reference is now made to Figure 1, which discloses preferred embodiments  
5 of the invention. Not included in the figures are various pieces of auxiliary  
6 equipment such as heat exchangers, condensers, pumps and compressors,  
7 which are not essential to the invention.

### 8 9 **Description of the Preferred Embodiment**

10  
11 In Figure 1, two downflow reactor vessels, 5 and 15, are depicted. The first  
12 stage reaction, hydrocracking, occurs in vessel 5. The second stage,  
13 hydrotreating, occurs in vessel 15. Each vessel contains at least one reaction  
14 zone. Vessel 5 is depicted as having three catalyst beds, while vessel 15 is  
15 depicted as possessing a single catalyst bed. The first reaction vessel 5 is for  
16 cracking a first hydrocarbon stream 1, which is comprised primarily of  
17 preheated Fischer-Tropsch wax and recycle hydrocarbon from fractionation.  
18 The hydrocarbon feed is partially converted into products in the reactor. The  
19 reactor effluent 14 comprises light vaporized hydrocarbons, distillate oils,  
20 heavy unconverted hydrocarbon, and excess hydrogen not consumed in the  
21 reaction. The effluent stream 14 is slightly cooled by heat exchange  
22 (Exchanger 20) before it is sent, as stream 17, to a hot high pressure  
23 separator (HHPS) 55. The second reaction vessel 15, a hydrotreater  
24 removes nitrogen-containing, oxygen-containing and unsaturated molecules  
25 from a second hydrocarbon stream 34. Stream 34 contains vapor from the  
26 HHPS, which is combined with preheated condensate from line 2.

27  
28 In the integrated process of this invention, a first hydrocarbon stream 1 is  
29 combined with a hydrogen-rich gaseous stream 4 to form a first feedstock 12  
30 which is passed to first reaction vessel 5. Hydrogen-rich gaseous stream 4  
31 contains greater than 50% hydrogen, the remainder being varying amounts of

1 light gases, including hydrocarbon gases. The hydrogen-rich gaseous stream  
2 4 shown in the drawing is a blend of make-up hydrogen 3 and recycle  
3 hydrogen 26. While the use of a recycle hydrogen stream is generally  
4 preferred for economic reasons, it is not required. First feedstock 1 may be  
5 heated in one or more exchangers or in one or more heaters (this is not  
6 depicted in Figure 1) before being combined with hydrogen-rich stream 4 to  
7 create stream 12. Stream 12 is then introduced to first reaction vessel 5,  
8 where the first stage, in which hydrocracking preferably occurs, is located.  
9 The second stage is located in vessel 15, where hydrotreating preferably  
10 occurs.  
11  
12 The effluent from the first stage, stream 14 is cooled in heat exchanger 20.  
13 Stream 14 emerges from exchanger 20 as stream 17 and passes to the  
14 HHPS 55. The liquid stream 36 emerges from the HHPS 55 and proceeds to  
15 further processing. A stream (not shown) may be taken from stream 36 and  
16 passed to a lubricant base oil plant. The lubricant plant (not shown)  
17 comprises a catalytic dewaxing unit followed by a hydrofinishing unit. Waxy  
18 material not converted in the dewaxer may be recycled to stream 1 for further  
19 processing, while dewaxed effluent is hydrofinished. The hydrofinished  
20 material is subsequently subjected to atmospheric distillation. Heavier  
21 streams may then be vacuumed distilled to produce light and heavy base  
22 hydrocarbon stocks.  
23  
24 The gaseous stream 34 emerges from the HHPS 55, and joins with stream 2,  
25 which comprises Fischer-Tropsch condensate, before entering vessel 15 for  
26 hydrotreating. Vessel 15 effluent is stream 18.  
27  
28 The second reaction zone, found in vessel 15, contains at least one bed of  
29 catalyst, such as hydrotreating catalyst, which is maintained at conditions  
30 sufficient for converting at least a portion of the nitrogen, oxygen and at least  
31 a portion of the unsaturated compounds in the second feedstock.

1 Stream 18, the second stage effluent (vessel 15), contains thermal energy  
2 which may be recovered by heat exchange with other process streams, such  
3 as in heat exchanger 10. The hydrotreater effluent stream 18 may also be  
4 cooled with air coolers (not shown). If necessary, wash water may be injected  
5 upstream of the air coolers to prevent the deposition of salts in the air cooler  
6 tubes. Second stage effluent 18 emerges from exchanger 10 as stream 19  
7 and is passed to cold high pressure separator CHPS 35. The liquid effluent of  
8 the CHPS 35, stream 42, passes to fractionation. Gaseous overhead stream  
9 26, comprising primarily hydrogen and some other light gases, passes to the  
10 compressor 40, where it is recompressed and passed as recycle to one or  
11 more of the reaction vessels and as a quench stream for cooling the reaction  
12 zones. Such uses of hydrogen are well known in the art.  
13  
14 Stream 26 may pass through an absorber (not shown) which includes means  
15 for contacting the stream with an alkaline aqueous solution, for removing  
16 contaminants such as hydrogen sulfide and ammonia which may be  
17 generated in the reaction zones. The hydrogen-rich gaseous stream 26 is  
18 preferably recovered from the absorber at a temperature in the range of  
19 38°C-149°C (100°F-300°F) or 38°C-93°C (100°F-200°F).  
20  
21 Stream 26 then flows into the recycle gas compressor suction. The recycle  
22 compressor delivers the recycle gas to vessel 5, as stream 4. Part of the  
23 recycle compressor discharge gas, now stream 4, is routed to the  
24 hydrocracker reactor, vessel 5, as quench to control the reactor temperature.  
25 The remaining recycle gas that is not used as quench is combined with  
26 make-up hydrogen to become the hydrocracker reactor feed gas. The  
27 hydrocracker reactor feed gas is heated by process streams before combining  
28 with the Fischer-Tropsch wax and recycle hydrocarbon stream 1.  
29  
30 Figure 2 illustrates the base invention of Figure 1 as adapted for fuels  
31 production. The hydrotreating reactor 15 is modified, in the fuels case, to

1 employ at least two beds, rather than one. Hydrogen, in line 27, is used as an  
2 inter-bed quench.

3  
4 Line 19, the cooled effluent of hydrotreater 15, passes to the hot high  
5 pressure separator 25, where it is separated into a gaseous stream 21 and a  
6 heavier stream 22. The gaseous stream 21 passes to the cold high pressure  
7 separator 35, where processing continues as described in the discussion of  
8 Figure 1, with overhead stream 26 passing to compressor 40 and liquid  
9 effluent 42 being further processed.

10  
11 Stream 22, the liquid effluent of hot high pressure separator 25, is combined  
12 with stream 36, shown in Figure 1.

13  
14 Stream 36 enters hot low pressure separator 65, where it is separated into  
15 overhead stream 44 and liquid effluent 37. Stream 44 combines with stream  
16 42 and proceeds to cold low pressure separator 70. Fuel gas is removed  
17 overhead while liquid effluent 43 is passed to fractionator 50.

18  
19 Stream 37 also passes to fractionator 50, where it is separated into overhead  
20 gasoline stream 28, naphtha stream 29, kerosene fraction 31 and diesel  
21 stream 32. Bottoms stream 33 is recycled to the hydrocracker 5. A preferred  
22 distillate product has a boiling point range within the temperature range  
23 121-371°C (250°F-700°F). A gasoline or naphtha fraction having a boiling  
24 point within the temperature range C<sub>5</sub>-204°C(C<sub>5</sub>-400°F) is also desirable.

25  
26 Figure 3 illustrates the base invention of Figure 1 as adapted for lubricant  
27 production. The hydrotreating reactor 15 is modified, in the lubricant case, to  
28 employ at least two beds, rather than one. Hydrogen, in line 27, is used as an  
29 inter-bed quench.

30

1 Stream 18, the effluent of hydrotreater 15, is cooled in heat exchanger 10 and  
2 passed, as stream 19 to cold high pressure separator 35, as depicted in  
3 Figure 1. Overhead stream 26 passes to compressor 40, as depicted in  
4 Figure 1 and liquid effluent 42 is further processed as depicted in Figure 2.  
5 Stream 44 combines with stream 42 and proceeds to cold low pressure  
6 separator 70. Fuel gas is removed overhead while liquid effluent 43 is passed  
7 to fractionator (not shown).  
8  
9 Stream 36, liquid effluent from the hot high pressure separator 55 is  
10 separated into gaseous stream 44 and liquid stream 37, as depicted in  
11 Figure 2, the fuels case. Unlike Figure 2, however, line 37 proceeds to  
12 lubricants processing (details not shown, but including dewaxing procedures)  
13 rather than passing to fractionator.